



## Mount Rainier National Park

### Sister Mountain Project

#### The Orphan Tsunami of 1700

<b>Overview</b>	Students read selections from a book by geologist Brian Atwater titled, "The Orphan Tsunami of 1700". A book about earthquake and tsunami threats that were detected by scientific sleuthing in mud, trees, and the writing of samurai, merchants, and peasants. As they read, students look for evidence of the scientific process, connections between science and culture, and the role of technology in science.
<b>Key Concepts</b>	Plate tectonics, scientific process, emergency preparedness, earthquakes and tsunami
<b>Grade Level</b>	9-12
<b>Objectives</b>	<p>Students will be able to:</p> <ul style="list-style-type: none"><li>• Explain why studying earthquakes and tsunami are important</li><li>• Describe what and where the Cascadia subduction zone is</li><li>• Describe the process and evidence that scientists used to determine if the Cascadia subduction zone could cause large, destructive earthquakes</li><li>• Describe how to detect and respond in case of earthquake or tsunami</li><li>• Describe what areas of the world may experience the direct effects of subduction zone earthquakes and tsunami</li></ul>
<b>Setting</b>	Classroom
<b>Timeframe</b>	6 or more 50 minute class periods depending on which activities are selected. More time should be allowed for in-class reading or in-class presentations
<b>Materials</b>	<ul style="list-style-type: none"><li>• Copies of Atwater, B., Musumi-Rokkaku, S., Satake, K., Tsuji, Y., Ueda, K., Yamguchi, D. (2005). <u>The Orphan Tsunami of 1700</u>. USGS, Reston, VA. In association with University of Washington Press, Seattle, WA. (ISBN 0295985356 \$24.95) Available on-line at <a href="http://pubs.usgs.gov/pp/pp1707/">http://pubs.usgs.gov/pp/pp1707/</a></li><li>• Copies of student handouts</li></ul>
<b>Vocabulary</b>	Tsunami, Scientific Process, Technology, Cascadia subduction zone, geographer, earthquake, seismic, kinship, inclined, geologic, recedes, incapable, surging, tidal, hearth, submergence, impasse, Juan de Fuca, potential, uplift, subsidence, liquefaction, and inundation
<b>Skills</b>	Reading, Analysis, Communication in writing, Drawing Conclusions,

<b>Benchmarks</b>	Science 1.1.3, 1.1.4, 1.2.1, 1.2.4, 1.3.4, 1.3.5, 2.1.1, 2.1.3, 2.1.4, 2.1.5, 2.2.1,3.1.1, 3.2.1 Writing 1.1-3, 2.1-3 (research components include 3.1-3.5) Communication 1.1-3, 2.1-5, 3.1-3.3 Social Studies 1.1.2, 2.1.2, Geography 1.1.2, 1.2.2, 2.3.2, 3.1.2, 3.2.2
<b>Background</b>	<p>The Orphan Tsunami was written by Brian Atwater and his associates to demystify scientific research and make this multicultural, multigenerational detective story accessible to the average reader.</p> <p>Framed in the early 1980's Atwater's book helps to settle a dispute among geophysicists regarding the earthquake danger imposed by the Cascadia subduction zone. (Page 8 has a good introduction to the climate of plate-tectonics amongst the geophysicists at the time). Some geophysicists of the time argued that the dynamics of the Cascadia subduction zone were different than other subduction zones and as such was NOT prone to large scale destructive tsunami inducing earthquakes that were observed elsewhere (Alaska, Peru, and Indian Ocean). Solving this problem was important for convincing local officials to consider the importance of tsunami and subduction zone earthquakes as a hazard in need of mitigation and planning especially in low-lying urban coastal areas.</p> <p><u>Problem:</u>Can Cascadia's subduction zone have large destructive earthquakes like other subduction zones do?</p> <p><u>Hypothesis:</u> If Cascadia experiences destructive subduction zone earthquakes like other subduction zones then there should be evidence of land level changes and tsunami caused by such earthquakes along the coastlines of the Cascadia subduction zone.</p> <p><u>Procedures:</u> Scientists searched for evidence of land level changes and tsunami's on the coastline and then correlated the evidence to known tsunamis from other subduction zones.</p> <p>The "orphaned tsunami of 1700" did not have a known cause so researchers began to look for evidence in Japan to support the idea that the tsunami resulted from a Cascadia earthquake.</p> <p><u>Data:</u> Stratigraphic columns (Cascadia and Japan) containing—sand sheets, buried trees, buried soils, and buried campfires. Carbon 14 analysis of dead trees and plants. Tree ring analysis (dendrochronology). Historical documents in Japan. Native accounts</p> <p><u>Conclusion:</u> Yes, Cascadia has experienced large, destructive subduction zone earthquakes leading to the initiation of at least one tsunami that traveled across the Pacific Ocean to Japan. Therefore...scientists, emergency planners, governmental officials, and citizens should be made aware of the danger and institute planning necessary for safe mitigation and responses to the hazard.</p>

<p><b>Procedure</b></p>	<p>Step 1: Distribute copies of the book <u>The Orphan Tsunami of 1700</u> and copies of selected student handouts.</p> <p>Step 2: Assign one or more of the following reading selections and activities</p> <p><u>Introduction (p. 3-5)</u> Have students read the introduction (p.3-5) and as they read:</p> <ol style="list-style-type: none"> <li>1. Write down 10 terms and define them based on the context of the piece</li> <li>2. Answer the following question stems and then discuss them in class or as small groups: <ul style="list-style-type: none"> <li>• What does the author mean when he uses the term “unusual seas”</li> <li>• Why is the 1700 Tsunami considered an orphan?</li> <li>• What do you remember about the December 2004 Indian Ocean earthquake?</li> <li>• What damage can be expected if we were to have a 9.0 earthquake in Cascadia?</li> </ul> </li> </ol> <p>OR</p> <ol style="list-style-type: none"> <li>1. Write a public service poster explaining how to detect a Tsunami and what to do if you are near a coastline in danger of a Tsunami.</li> </ol> <p><u>Part 1--Unearthed earthquakes (p. 17-25)</u> Have students read Part 1 (p. 17-25) and as they read</p> <ol style="list-style-type: none"> <li>1. Write down 10 terms and define them based on the context of the piece</li> <li>2. Answer the following question stems and then discuss them as a class or in small groups: <ul style="list-style-type: none"> <li>• How much evacuation time do local populations have to evacuate coastal areas?</li> <li>• Look at a map of the coast (Washington, Oregon and N. California). What places have you visited or would you like to visit that lie along the coast in a Tsunami Hazard area?</li> <li>• What problem were scientists in the story trying to solve?</li> <li>• Why were these scientists using tsunami as evidence for earthquakes?</li> <li>• Describe how an earthquake causes a Tsunami in at least 3 steps.</li> <li>• Explain at least 4 pieces of geologic evidence that Tsunamis leave behind?</li> </ul> </li> </ol> <p>OR</p> <ol style="list-style-type: none"> <li>1. Group students into 5 groups and assign each group one of the following pieces of evidence —(1) native flood stories, (2) buried forests and sunken shores, (3) sand sheets, (4) buried native campsites, (5) cracks and currents</li> <li>2. Have each group research and prepare a poster/presentation of their form of evidence. As students research they should consider the following: <ul style="list-style-type: none"> <li>• How does land level change or tsunami form that piece of evidence?</li> </ul> </li> </ol>
-------------------------	--

- Where has that form of evidence been found (Cascadia? Rest of the world?)
  - What to look for to find this form of evidence
3. Students can then jig-saw and share their information OR they can present their information to the rest of the class.
  4. Provide students with a Cascadia map to make notes on as they listen to presentations or work together.

OR

Students can design a “geobox” (see resources) for tsunami instead of volcanic rocks.

### Part 2—Orphan Tsunami (27-91)

Have students read Part 2 (27-91). I would NOT have them read the entire section.

1. Assign each student a different selection and then have him or her prepare a report or presentation for the class
2. Assign each student a different selection and then have him or her do a 1-2-3 summary. 1—main idea, 2—supporting details, and 3—interesting facts

OR

Have students read only the pages about each village and the historical account (pp. 36-39, 50-52, 58-60, 66-69, 76-79, 84-87) then complete the [“orphan tsunami” graphic organizer](#).

OR

Jigsaw (see part 1) students to research one village and then rearrange groups to share and complete the graphic organizer. Finalize the jigsaw activity by having students answer the following question stems and discussing them in class:

- What are the dangers associated with Tsunamis?
- Describe the tectonic situation that is necessary to generate a Tsunami.
- About how often do Tsunamis collide with Japan?

OR

Write a narrative for an OBJECT (such as a fish, a piece of sand on the shore, a rock on the shore, a boat in the water, a tree on the hill etc.) living through a Tsunami. Students should personify their chosen object and explain what such an object would see, smell, and hear beginning with the earthquake (or lack of) and then continue through several waves to the final sunken position of the shore.

### Simulated Waves (p.74-75)

This section is a series of illustrations from a computer model. There is an on-line animated version of the simulation. The URL is listed in the caption. Lead students in a discussion of what a model is and how the simulation meets the criteria for a model. As you lead students through the diagrams, discuss the following topics.

1. Where does the tsunami begin?
2. What causes the tsunami?
3. What kind of energy is between the plates before the earthquake? (potential)
4. What kind of energy does it become when the earthquake occurs?

	<p>(kinetic, sound, heat)</p> <ol style="list-style-type: none"> <li>Where does the kinetic energy transfer to? (water and then the shore of Japan and then back again)</li> <li>How long does it take for the tsunami to reach the Pacific coast?</li> <li>What happens to the waves when they reach Hawaii? (some are reflected back towards the coastline)</li> <li>How long does it take for the tsunami to reach Japan?</li> <li>What other places experience the tsunami?</li> <li>Why aren't the waves in a perfect circle like dropping a rock in a pond? (they are reflected when they collide with other islands and topography)</li> <li>About how long will it take for waves reflected from Japan to reach the coast again? (11 to 12 hours a second series of waves will occur. This is a potential danger for people who think it is safe to return to their coastal homes soon after the first set of waves are done) (additional high surges may occur as waves reflect from other continents as well)</li> <li>How long do waves continue to reflect across the Pacific Ocean? (don't know...still going at 23 hours. Would have to run the model for longer)</li> </ol> <p><u>Part 3—The Orphan's Parent</u></p> <p>Have students read p. 93-105</p> <p>Answer the following question stems and then discuss them as a class or in small groups:</p> <ol style="list-style-type: none"> <li>Why evidence supports the conclusion that the 1700 tsunami originated in Cascadia?</li> <li>How did tree rings help scientists to provide even stronger support that the 1700 tsunami originated in Cascadia?</li> <li>In the last 3,500 years, how many earthquakes have occurred along the Cascadia subduction zone?</li> <li>Calculate the recurrence interval by dividing time by the number of earthquakes.</li> <li>Predict when the next earthquake could likely occur.</li> <li>Is that date guaranteed? Explain your answer</li> <li>What are some places that are at risk of danger during a Cascadia earthquake?</li> <li>Are hazards restricted to those living on coasts? Explain your answer.</li> <li>If there were to be a cascadia earthquake, what are the dangers to where you live, work and go to school?</li> </ol>
<b>Adaptations</b>	To help students with geography, do the mapping activity "Mapping the Rim " before beginning this activity.
<b>Extensions</b>	<p>Students can research other Tsunami (Alaska, Indian Ocean, Peru). See Resources for internet research suggestions.</p> <p>Use the first person accounts found in "Surviving a Tsunami" to write a script to perform for the rest of the class</p>

	Take students on a field trip to an ocean beach to discuss evacuation, signs of tsunami inundation, and other oceanographic concepts.
<b>Assessment</b>	<p>Design a public service announcement providing details for what to do in the case of a Tsunami.</p> <p>Write a lab report chronicling the scientist's use of the scientific process</p> <p>Formulate a disaster plan for the family including— what to do at home, work, and school, an outside contact person, a meeting area etc. Ideas can be found on the FEMA website. See also "Don't be scared, Be Prepared" activity for ideas.</p> <p>Using a plate tectonic map, have students predict other areas of the world that are most likely to experience tsunami risk and places least likely to experience tsunami risk</p>
<b>References</b>	<p>Atwater, B., Musumi-Rokkaku, S., Satake, K., Tsuji, Y., Ueda, K., Yamguchi, D. (2005). <u>The Orphan Tsunami of 1700</u>. USGS, Reston, VA. In association with University of Washington Press, Seattle, WA. (ISBN 0295985356 \$24.95) Available on-line at <a href="http://pubs.usgs.gov/pp/pp1707/">http://pubs.usgs.gov/pp/pp1707/</a></p>
<b>Resources</b>	<p>Atwater, B., Musumi-Rokkaku, S., Satake, K., Tsuji, Y., Ueda, K., Yamguchi, D. (2005). <u>The Orphan Tsunami of 1700</u>. USGS, Reston, VA. In association with University of Washington Press, Seattle, WA. (ISBN 0295985356 \$24.95) Available on-line at <a href="http://pubs.usgs.gov/pp/pp1707/">http://pubs.usgs.gov/pp/pp1707/</a></p> <p>Atwater, B. and others. (1999) <u>Surviving a tsunami</u>. U.S. Geological Survey Circular 1187 Version 1.1. United States Geological Survey. (2005 revision) <a href="http://pubs.usgs.gov/circ/c1187/">http://pubs.usgs.gov/circ/c1187/</a></p> <p>Atwater, T. "Educational multimedia visualization center" University of California, Santa Barbara. Available online at <a href="http://animations.geol.ucsb.edu/">http://animations.geol.ucsb.edu/</a></p> <p>"Cascadia, The hidden fire" DVD. Available for purchase on <a href="http://www.globalnetproductions.com/volca.html">http://www.globalnetproductions.com/volca.html</a></p> <p>Driedger, C., Doherty, A., &amp; Dixon, C. (2005) "Don't be scared, be prepared." <u>Living with a volcano in you back yard-an educator's guide with emphasis on Mt Rainier</u>. General Information Publication 19. Available on-line at <a href="http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_three_dont_be_scared.pdf">http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_three_dont_be_scared.pdf</a></p> <p>Driedger, C., Doherty, A., &amp; Dixon, C. (2005) "Shoebox Geologist." <u>Living with a volcano in you back yard-an educator's guide with emphasis on Mt Rainier</u>. General Information Publication 19. Available on-line at <a href="http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_two_shoebox_geologist.pdf">http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_two_shoebox_geologist.pdf</a></p>

Montagne, R. (2005). "Unearthing proof of a tsunami in the Northwest" National Public Radio. Morning Edition. Transcript and podcast available online at <http://www.npr.org/templates/story/story.php?storyId=4629401>

Oregon Department of Geology and Mineral Industries. "Tsunami hazard maps for the Oregon coast". Available online at <http://www.oregongeology.com/sub/earthquakes/coastal/Tsumapsbycity.HTM>

University of California. Tsunami Research Center.  
<http://cwis.usc.edu/dept/tsunamis/2005/index.php>

Washington State Department of Natural Resources. "Tsunami evacuation brochures." Available online at <http://www.dnr.wa.gov/ResearchScience/Topics/GeologyPublicationsLibrary/Pages/tsuevac.aspx>